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(54) **TRANS-REFLECTIVE LIQUID CRYSTAL
DISPLAY ARRAY SUBSTRATE,
MANUFACTURING METHOD THEREOF AND
DISPLAY DEVICE**

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G02F 2201/40 (2013.01)

(58) **Field of Classification Search**

CPC **G02F 1/133555**; **G02F 1/133371**
USPC **349/114, 110–111**
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,789,761 A 8/1998 Ihara et al.
6,683,667 B2 1/2004 Jin et al.
2014/0111747 A1 4/2014 Wang et al.

FOREIGN PATENT DOCUMENTS

CN 1924654 A 3/2007
CN 101067706 A 11/2007
CN 102681245 A 9/2012

OTHER PUBLICATIONS

International Preliminary Report on Patentability for International
Application No. PCT/CN2012/085566 dated Sep. 16, 2014, 11pgs.

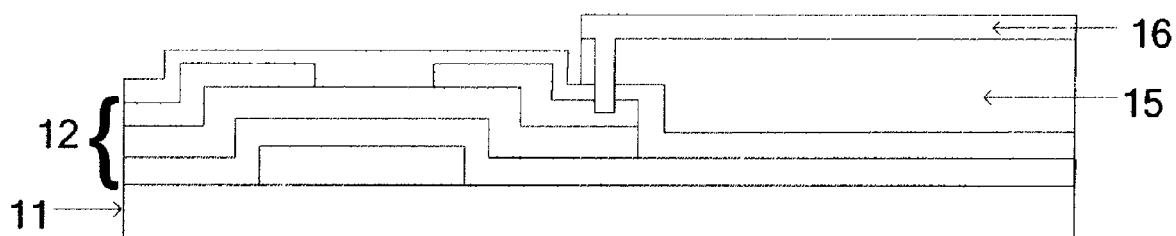
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Primary Examiner — Phu Vu

(57) **ABSTRACT**

A trans-reflective liquid crystal display array substrate and a manufacturing method thereof. The trans-reflective liquid crystal display array substrate (11) includes a substrate (11) and a thin film transistor (12) provided thereon. A black matrix (13) is provided on the thin film transistor (12) and a reflective layer (14) is located on the black matrix (14). The brightness of the liquid crystal display panel is increased by enlarging the pixel aperture ratio.

15 Claims, 4 Drawing Sheets



(56)

References Cited

OTHER PUBLICATIONS

First Office Action for Chinese patent application 201210102142.X (Chinese language), issued by the State Intellectual Property Office, Oct. 23, 2013, 7 pages.

English translation of the First Office Action for CN201210102142.X, listed above, 4 pages.

PCT International Search Report (Chinese language) issued by the International Searching Authority, Mar. 15, 2013, 14 pages.

English translation of CN102681245, listed above, 16 pages.

English translation of CN1924654, listed above, 12 pages.

English translation of CN101067706, listed above, 19 pages.

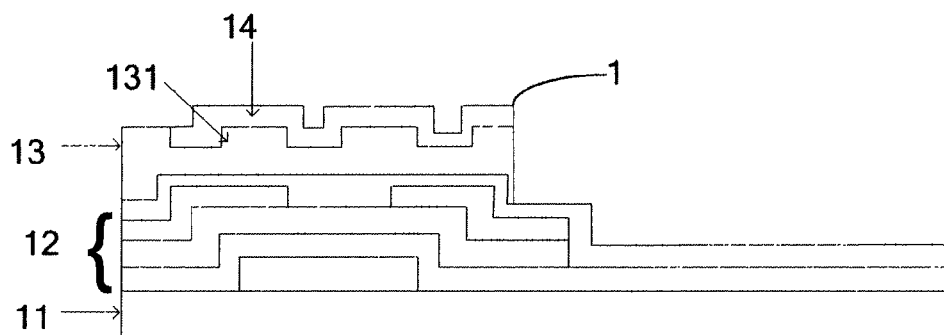


FIG. 1

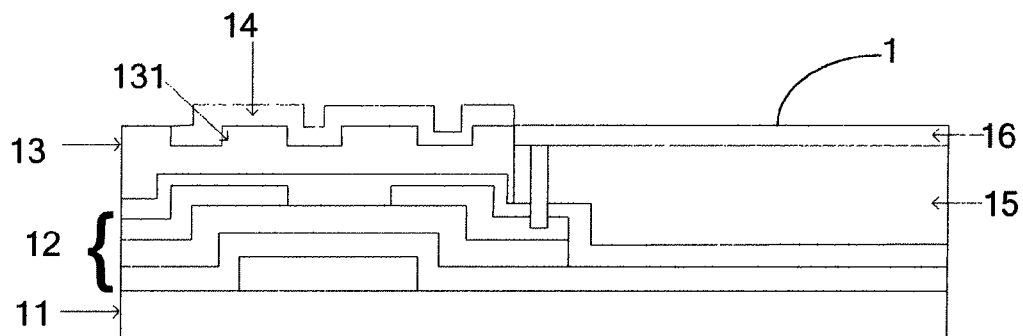


FIG. 2

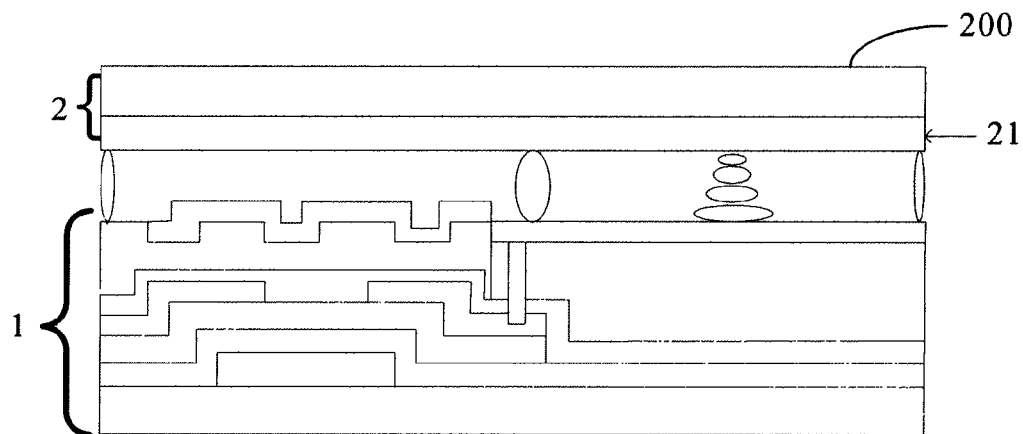


FIG. 3

R	G	B
R	G	B
R	G	B

FIG. 4

R	G	B
B	R	G
G	B	R

FIG. 5

R	G	B	
	B	R	G
G	B	R	

FIG. 6

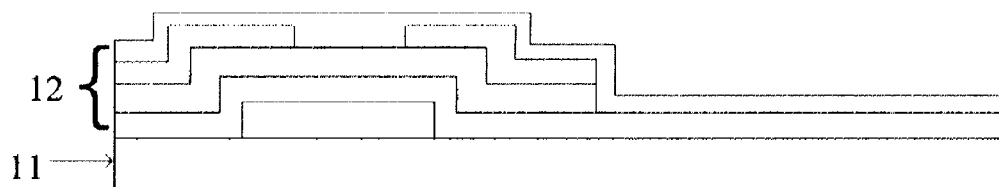


FIG. 7

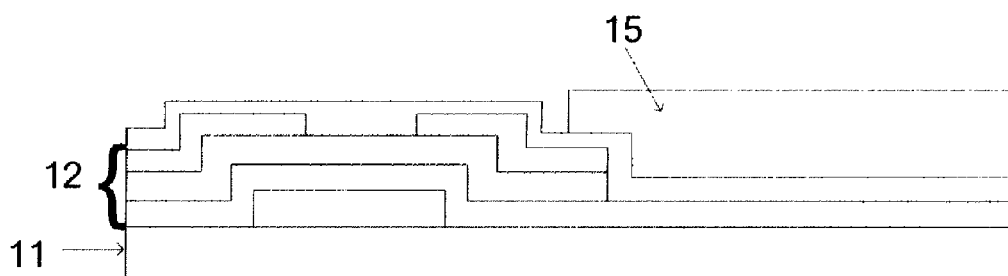


FIG. 8

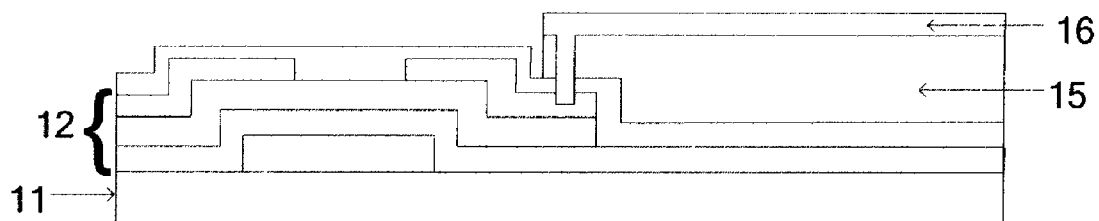


FIG. 9

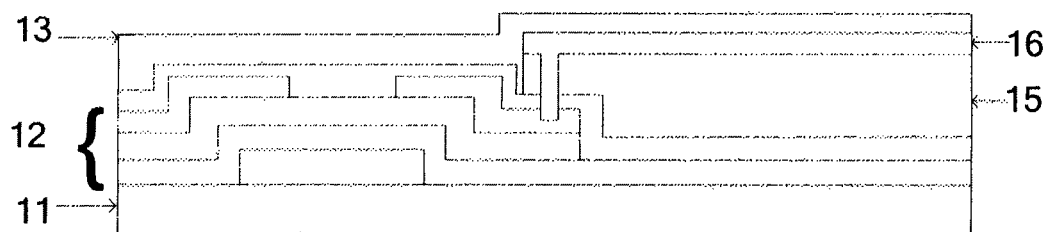


FIG. 10

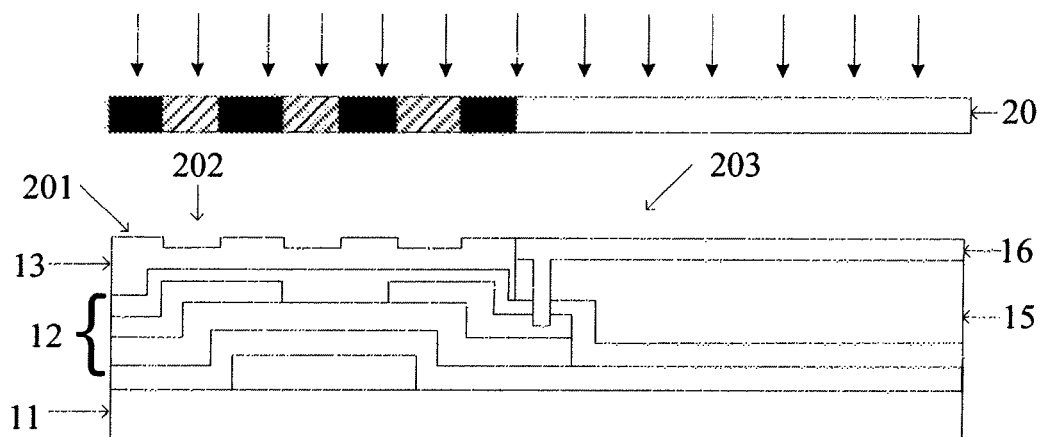


FIG. 11

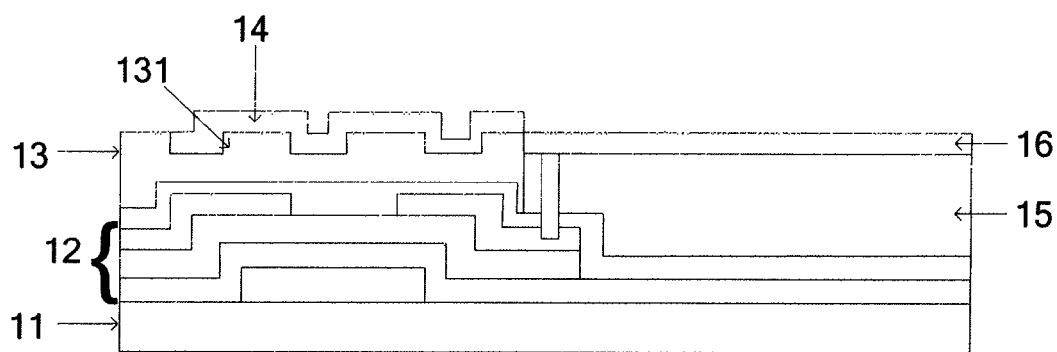


FIG. 12

1

TRANS-REFLECTIVE LIQUID CRYSTAL DISPLAY ARRAY SUBSTRATE, MANUFACTURING METHOD THEREOF AND DISPLAY DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is based on International Application No. PCT/CN2012/085566 filed on Nov. 29, 2012 which claims priority to Chinese Application No. 201210065942.4 filed on Mar. 15, 2012 and Chinese Application No. 201210102142.X filed on Apr. 9, 2012, the contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

The embodiments of the present invention relate to a trans-reflective liquid crystal display array substrate and a manufacturing method thereof.

BACKGROUND OF THE INVENTION

Thin film transistor liquid crystal display (TFT-LCD) is a non-self-luminous flat panel display, which needs external light source to provide light required for image displaying. Based on the type of the external light source, the thin-film transistor liquid crystal display can generally be divided into reflective thin film transistor liquid crystal display with ambient light as the light source, transmissive thin film transistor liquid crystal display with a backlight assembly as the light source, and trans-reflective thin film transistor liquid crystal display having characteristics of both the above two types.

The main feature of the trans-reflective liquid crystal display is dividing the pixel in a conventional thin film transistor liquid crystal display into a transmissive sub-pixel electrode made of a transparent conductive material and a reflective sub-pixel electrode made of a metal material, and simultaneously driving the transmissive and reflective sub-pixels by using a pixel circuit provided at an intersecting region between a scanning line and a data line. In the prior art, the reflective layer is disposed in a pixel region with RGB color filters, and thus, it will cause that the part of the pixel region is reduced in area, the pixel aperture ratio is decreased, thereby affecting the brightness of the liquid crystal display panel.

SUMMARY OF THE INVENTION

One embodiment of the invention provides a trans-reflective liquid crystal display array substrate, comprising a substrate and a thin film transistor provided on the substrate, wherein, a black matrix and a reflective layer located on the black matrix are provided over the thin film transistor.

Another embodiment of the invention provides a trans-reflective liquid crystal display panel, comprising the array substrate as mentioned above, further comprising a color filter substrate opposed to and bonded with the array substrate.

A further embodiment of the invention provides display device comprising the trans-reflective liquid crystal display panel as mentioned above.

Still another embodiment of the invention provides manufacturing method of a trans-reflective liquid crystal display array substrate, comprising: forming a thin film transistor on a substrate; depositing a protective layer on the substrate formed with the thin film transistor, and performing a pattern-

2

ing process; forming a pixel electrode layer on the protective layer, and performing one patterning process on the pixel electrode layer in such a way that the pixel electrode layer covers a region same as the protective layer, and the pixel electrode layer is connected to a drain electrode of the thin film transistor; forming a black matrix on the thin film transistor; a gate line and a data line on the substrate; and forming a reflective layer on the black matrix.

In the trans-reflective liquid crystal display substrate and the manufacturing method thereof, the black matrix is provided on the TFT array substrate, and the reflective film, which is disposed on the pixel electrode in the prior art, is provided on the black matrix, which enlarge the transmissive area of a pixel unit and increase the aperture ratio of the pixel. Further, since the pixel electrode is provided above the protective layer and the distance between the data line of the TFT and the pixel electrode, the capacitance between the pixel electrode and the data line is reduced, the stability of the trans-reflective liquid crystal display substrate is enhanced, and further the brightness of the liquid crystal is increased.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to clearly illustrate the technical solutions of the embodiments of the invention, the drawings of the embodiments will be briefly described in the following; it is obvious that the described drawings are only related to some embodiments of the invention and thus are not limitative of the invention.

FIG. 1 is a structural schematic diagram of a trans-reflective liquid crystal display array substrate according to an embodiment of the invention;

FIG. 2 is a structural schematic diagram of another trans-reflective liquid crystal display array substrate according to an embodiment of the invention;

FIG. 3 is a structural schematic diagram of a trans-reflective liquid crystal display panel according to an embodiment of the invention;

FIG. 4 is a structural schematic diagram illustrating arrangement of color filter films in a color filter substrate according to an embodiment of the invention;

FIG. 5 is a structural schematic diagram illustrating arrangement of color filter films in another color filter substrate according to an embodiment of the invention;

FIG. 6 is a structural schematic diagram illustrating arrangement of color filter films in another color filter substrate according to an embodiment of the invention;

FIG. 7 is a first structural schematic diagram of an array substrate according to an embodiment of the invention;

FIG. 8 is a second structural schematic diagram of the array substrate according to the embodiment of the invention;

FIG. 9 is a third structural schematic diagram of the array substrate according to the embodiment of the invention;

FIG. 10 is a fourth structural schematic diagram of the array substrate according to the embodiment of the invention;

FIG. 11 is a fifth structural schematic diagram of the array substrate according to the embodiment of the invention; and

FIG. 12 is a sixth structural schematic diagram of the array substrate according to the embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to make objects, technical details and advantages of the embodiments of the invention apparent, the technical solutions of the embodiments will be described in a clearly and fully understandable way in connection with the draw-

ings related to the embodiments of the invention. It is obvious that the described embodiments are just a part but not all of the embodiments of the invention. Based on the described embodiments herein, those skilled in the art can obtain other embodiment(s), without any inventive work, which should be within the scope of the invention.

First Embodiment

The embodiment of the invention provides a trans-reflective LCD array substrate, as illustrated in FIG. 1. The trans-reflective LCD array substrate **1** includes: a substrate **11**, a thin film transistor **12**, a gate line and a data line (not shown in FIG. 1). A black matrix **13** is provided on the thin film transistor **12**, the gate line and the data line (not shown in FIG. 1), and a reflection layer **14** is provided on the black matrix **13**.

In the embodiment of the invention, the black matrix **13** is formed with protrusions **131** after exposure by using a grey tone and a half tone mask. For example, the protrusions **131** are formed in a region of the thin film transistor on the array substrate. The region of the thin film transistor is a region where the thin film transistor is located on the array substrate. The thin film transistor **12** mainly comprises a gate electrode, a gate insulating layer, a semiconductor active layer, a source electrode, a drain electrode, etc.

The protrusions **131** formed on the black matrix **13** diffusely reflect the external light entering into the liquid crystal display array panel, so that the light can be uniformly reflected. That is, the reflective layer **14** is conformally formed on the black matrix **13** formed with the protrusions **131** in the region corresponding to the thin film transistor. The reflective film, which is provided on the pixel electrode, is provided on the black matrix in the present embodiment, so that the light transmittance area of a pixel unit is increased, the aperture ratio of the pixel becomes large, and further the brightness of the liquid crystal display substrate is enhanced.

Further, the reflective layer **14** is coated on the protrusions **131** of the black matrix **13** in the embodiment of the present invention, and diffusely reflects the external light entering into the array substrate of the liquid crystal display, so that the light can be reflected out of the liquid crystal display panel uniformly, and the brightness of the liquid crystal display panel is improved.

The reflective layer **14** may be a metal layer with reflection effect, for example, metals such as molybdenum or aluminum-neodymium.

Further, as illustrated in FIG. 2, the array substrate **1** provided by the embodiment of the invention further comprises:

A protective layer (OC) **15** and a pixel electrode **16** connected to the drain electrode of the thin film transistor on the substrate **11**.

The protective layer **15** is deposited on the substrate **11** formed with the thin film transistor **12**, and is connected with the black matrix **13** and covers the same region as the pixel electrode **16**; the black matrix **13** is formed on the substrate **11** formed with the thin film transistor **12**, the gate line and the data line (not shown in FIG. 1), and covers the entirety of the region of the thin film transistor device, and the region is a region of the array substrate where the thin film transistor is located on.

In one example, the reflective layer may be connected with the drain electrode of the thin film transistor. Therefore, the reflective layer may have a function of a reflective electrode. The electrical connection between the reflective layer and the drain electrode of the thin film transistor is not particularly limited. For example, the reflective layer **14** may be connected with the pixel electrode layer **16** which is connected to the drain electrode.

In the trans-reflective liquid crystal display substrate provided in the embodiment of the invention, the black matrix is provided on the TFT array substrate, and the reflective film, which is disposed on the pixel electrode in the prior art, is provided on the black matrix, which enlarges the transmissive area of a pixel unit, increases the aperture ratio of the pixel and further enhances the brightness of the liquid crystal display panel. Further, in the embodiment of the invention, since the pixel electrode is provided above the protective layer and the distance between the data line of the TFT and the pixel electrode is increased, the capacitance between the pixel electrode and the data line is reduced, the stability of the trans-reflective liquid crystal display substrate is enhanced, and further the displaying effect of the liquid crystal is improved.

Second Embodiment

As illustrated in FIG. 3, the present embodiment of the invention also provides a trans-reflective liquid crystal display panel **200**, including an array substrate **1** and a color filter substrate **2** which is opposed to and bonded with the array substrate. The color filter substrate **2** is formed with continuously arranged color filter films **21** thereon.

It should be noted that, the array substrate provided in the present embodiment has the same structure as that in the first embodiment; therefore the description on the structure of the array substrate **1** is not repeated here.

Specifically, as illustrated in FIG. 4, the color filter films **21** include a red color region R, a green color region G and a blue color region B, and the red color region R, the green color region G and the blue color region B are arranged in a strip manner, i.e., the color filter films in one column are color filter films of the same color, the color filter films in each column are connected with one another.

Alternatively, as illustrated in FIG. 5, for the color filter films **21**, the red color region R, the green color region G and the blue color region B are arranged in a mosaic manner, i.e., the red color region R, the green color region G and the blue color region B are sequentially arranged with regions of the same color located at the diagonal positions.

Alternatively, as illustrated in FIG. 6, for the color filter films **21**, the red color region R, the green color region G and the blue color region B in two adjacent rows are staggered with each other. As compared with FIG. 3 and FIG. 4, in the arrangement pattern, the color regions are shifted by a half of the width of the color region towards the right side or the left side for every other row.

In the trans-reflective liquid crystal display panel provided in the embodiment of the invention, the black matrix is provided on the TFT array substrate, and the reflective film, which is disposed on the pixel electrode in the prior art, is provided on the black matrix, which enlarges the transmissive area of a pixel unit, increases the aperture ratio of the pixel and further enhances the brightness of the liquid crystal display panel. Further, in the embodiment of the invention, since the pixel electrode is provided above the protective layer and the distance between the data line of the TFT and the pixel electrode is increased, the capacitance between the pixel electrode and the data line is reduced, the stability of the trans-reflective liquid crystal display substrate is enhanced, and further the displaying effect of the liquid crystal is improved.

Third Embodiment

Hereinafter, a manufacturing method of a trans-reflective liquid crystal display array substrate is described by connection with FIGS. 7 to 12.

First, a manufacturing method of the TFT array substrate in the liquid crystal display is described, the method comprises the following steps.

S701, a thin film transistor **12** is formed on a substrate **11**.

5

As illustrated in FIG. 7, the thin film transistor **12** includes a gate electrode, a gate insulating layer, a semiconductor active layer, a source electrode, a drain electrode, etc.

S702, a protective layer **15** is deposited on the substrate formed with the thin film transistor **12**, and a patterning process is performed.

For example, as illustrated in FIG. 8, an organic resin is applied on the substrate to form the protective layer **15**, and the protective layer **15** is patterned so that the protective layer **15** is formed on a region for forming a pixel electrode on the substrate.

S703, a pixel electrode layer **16** is deposited on the protective layer **15**, and the pixel electrode layer **16** is patterned so that it covers a same area as the protective layer and connected to the drain electrode.

For example, as illustrated in the figures, an indium tin oxide (ITO) layer is deposited on the protective layer **15**. By one patterning process, the pixel electrode layer **16** is formed and a through-hole is formed in the pixel electrode layer **16**, so that the pixel electrode layer **16** is connected to the drain electrode. In the embodiment of the invention, the pixel electrode layer **16** is provided on the protective layer **15**, and the pixel electrode layer **16** and the protective layer **15** covers the same area due to they being subjected to one patterning process. After the protective layer **15** is provided, the distance between the pixel electrode layer and the data line of the thin film transistor on the array substrate is increased, thereby reducing the capacitance between the pixel electrode layer and the data line, and enhancing the stability of image displaying of the liquid crystal display, thus helping to improve the screen displaying effect of the liquid crystal display.

S704, black photoresist **13** is applied on the substrate **11**.

For example, as illustrated in FIG. 10, a layer of black photoresist **13** is coated on the substrate, and the black photoresist **13** is a structure of black matrix which has not been subjected to processing and treatment on the array substrate.

S705, by using a gray tone mask or half tone mask **20**, the black photoresist **13** is patterned.

As illustrated in FIG. 11, specifically, after the photoresist **13** is patterned, a black photoresist completely retained region **201**, a black photoresist partially retained region **202** and a black photoresist completely removed region **203** are formed. In one pixel unit, the black photoresist completely retained region **201** and the black photoresist partially retained region **202** correspond to a region in which the black matrix is located on the thin film transistor, the black photoresist completely removed region **203** correspond to the region for the pixel electrode.

After the black photoresist is exposed and developed, the black photoresist in the completely removed region **203** is removed, and the black matrix is formed. The black photoresist in the partially retained region **202** is partially removed so that the completely retained region **201** is formed into protrusions with respect to the partially retained region **202**, which will diffusely reflect the light entering into the liquid crystal display.

S706, a reflective layer **14** is deposited on the black matrix **13** formed with the protrusions **131**.

Specifically, as illustrated in FIG. 12, the reflective layer **14** is deposited on the black matrix **13**; after an etching process, the reflective layer **14** is retained on the black matrix **13** with the protrusions **131**, so as to diffusely reflect the external light entering into the liquid crystal display substrate, uniformly reflect the light out of the liquid crystal display panel, and improve the brightness of the liquid crystal display panel. That is, the reflective layer **14** is formed conformally on the

6

black matrix **13** formed with the protrusions **131** in the region corresponding to the thin film transistor.

The reflective layer **14** may be a metal layer with reflection effect, and the metal can be, for example, molybdenum or aluminum-neodymium.

In one example, the reflective layer may be connected to the drain electrode of the thin film transistor. Therefore, the reflective layer may function as a reflective electrode. The electrical connection between the reflective layer and the drain electrode of the thin film transistor is not particularly limited. For example, the reflective layer **14** may be connected to the pixel electrode layer **16** connected with the drain electrode.

A manufacturing method of a color filter substrate in the liquid crystal display will be described. Color filter films including a red color region, a green color region, and a blue color region are deposited on the color filter substrate. During the deposition of the color filter films, the red color region, the green color region, and the blue color region is continuously arranged.

For example, the red color region, the green color region, and the blue color region of the color filter films are deposited so as to form in a strip-like arrangement, a mosaic arrangement, or an arrangement in which the color regions continuously arranged in two adjacent rows are staggered.

It should be noted that, in the manufacturing process of the TFT array substrate of the trans-reflective liquid crystal display provided in the embodiment of the present invention, the black matrix and the pixel electrode layer are in the same plane; therefore, the method described in the step **S703** and the steps **S704** to **S705** can be performed in different sequences.

In the manufacturing method of the trans-reflective liquid crystal display substrate provided in the embodiments of the invention, the black matrix is provided on the TFT array substrate, and the reflective film, which is disposed on the pixel electrode in the prior art, is provided on the black matrix, which enlarges the transmissive area of a pixel unit, increases the aperture ratio of the pixel, and further increases the brightness of the liquid crystal display substrate. Further, in the embodiments of the invention, since the pixel electrode is provided above the protective layer and the distance between the data line of the TFT and the pixel electrode, the capacitance between the pixel electrode and the data line is reduced, the stability of the trans-reflective liquid crystal display substrate is enhanced, and further the brightness of the liquid crystal is increased.

The above description is only exemplary implementations of the present invention, but not for limiting the scope of the invention; instead, the scope of the invention should be defined by the appended claims.

What is claimed is:

1. A trans-reflective liquid crystal display array substrate, comprising a substrate and a thin film transistor provided on the substrate, wherein,

a black matrix and a reflective layer located on the black matrix are provided over the thin film transistor; the array substrate further comprises a protective layer and a pixel electrode provided above the protective layer and connected to a drain electrode of the thin film transistor; wherein, the protective layer is connected with the black matrix and covers a same region as the pixel electrode.

2. The trans-reflective liquid crystal display array substrate according to claim 1, wherein the reflective layer is electrically connected to a the drain electrode of the thin film transistor.

7

3. The trans-reflective liquid crystal display array substrate according to claim 1, wherein a plurality of protrusions are formed on the black matrix.

4. The trans-reflective liquid crystal display array substrate according to claim 3, wherein the protrusions are formed in a region of the array substrate where the thin film transistor is located.

5. The trans-reflective liquid crystal display array substrate according to claim 1, wherein the reflective layer is formed on the protrusions of the black matrix.

6. The trans-reflective liquid crystal display array substrate according to claim 5, wherein the reflective layer is a metal layer having a reflection effect.

7. The trans-reflective liquid crystal display array substrate according to claim 6, wherein material of the metal layer for forming the reflective layer is molybdenum or aluminum-neodymium.

8. A trans-reflective liquid crystal display panel, comprising the array substrate according to claim 1, further comprising a color filter substrate opposed to and bonded with the array substrate.

9. A manufacturing method of a trans-reflective liquid crystal display array substrate, comprising:

forming a thin film transistor on a substrate;

depositing a protective layer on the substrate formed with the thin film transistor, and performing a patterning process;

forming a pixel electrode layer on the protective layer, and performing one patterning process on the pixel electrode layer in such a way that the pixel electrode layer covers a region same as the protective layer, and the pixel electrode layer is connected to a drain electrode of the thin film transistor;

forming a black matrix on the thin film transistor, a gate line and a data line on the substrate; and

forming a reflective layer on the black matrix.

8

10. The manufacturing method of the trans-reflective liquid crystal display array substrate according to claim 9, wherein the reflective layer is electrically connected to the drain electrode of the thin film transistor.

11. The manufacturing method of the trans-reflective liquid crystal display array substrate according to claim 9, wherein forming the black matrix on the substrate formed with the thin film transistor comprising:

applying black photoresist on the substrate;

patterning the black photoresist by using a gray tone mask or a half tone mask so as to form a black photoresist completely retained region, a black photoresist partially retained region and a black photoresist completely removed region; wherein, in the pixel unit, the black photoresist completely retained region and the black photoresist partially retained region correspond to a region of the thin film transistor, the black photoresist completely removed region corresponds to a region of the pixel electrode.

12. The manufacturing method of the trans-reflective liquid crystal display array substrate according to claim 11, wherein the protrusions are formed in a region of the array substrate where the thin film transistor is located.

13. The manufacturing method of the trans-reflective liquid crystal display array substrate according to claim 9, wherein the reflective layer is formed on the protrusions of the black matrix.

14. The manufacturing method of the trans-reflective liquid crystal display array substrate according to claim 13, wherein the reflective layer is a metal layer having a reflection effect.

15. The manufacturing method of the trans-reflective liquid crystal display array substrate according to claim 14, wherein material of the metal layer for forming the reflective layer is molybdenum or aluminum-neodymium.

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